

Designing digital texts for beginner readers: performance, practice and process

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Designing digital texts for beginner readers: aspects and processes

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1 Introduction

This chapter describes the role of research in typography and graphic communication and in information design, that is relevant to the design and use of materials for children's reading. By 'design' in this context we mean 'typography' (which is the visual organisation of type and pictures on paper or screen), and 'process' (the ways in which design is developed in order to make sure that what is designed works for its intended reader group).

Much of what we know about the impact of design on reading comes from the field of legibility research. 'Legibility' in this context is the speed and accuracy with which text on a page can be read (after Pyke 1926; Zachrisson 1965; and dos Santos Lonsdale 2014). In this chapter we present findings from legibility research within a broader framework of considerations that designers use when they organise text and pictures on page or screen. These findings will highlight the multi-variate nature of design decision-making, which makes it resistant to strong rule-bound recommendations. The substrate – screen or paper, for example – on which reading materials are displayed is one of the variables that designers must take into account. Most of the research we refer to is concerned with reading on paper, rather than reading on screen. Therefore we consider how much of this research is transferable directly to children's digital reading and suggest that, in the absence of guidelines that can be applied universally, an information design approach may be a helpful alternative. Such an approach emphasises the importance of understanding the needs of and eliciting feedback from beginner and emerging readers (and indeed those who read with them) to find out which typographic attributes enhance the reading experience.

We have organised this paper by first summarising the issues that designers consider when they produce material for beginner and emerging readers. This is followed by a discussion about typography and the use of space, and a short section about the interrelation of text and illustrations. This is then set in the technological context of e-reading and the impact that such technology has on design decisions. Finally, we look at ways of engaging with the users of e-books for beginner and emerging readers to suggest approaches to designing with their needs in mind.

We recognise that use of digital resources for beginning and emerging readers in schools is expanding and use of tablet devices at home is widespread. Actual penetration in both spheres is hard to track because of rapid change: in 2014 in the UK it was estimated that tablet devices were used in 60% of primary schools (TechKnowledge, 2014). Many e-books for beginner and emerging readers are multi-modal, incorporating sound and animation as well as pictures and text. There is a considerable literature on what Bateman refers to as ‘modalities of information presentation’, covering the dynamic of text and image and how both can be used to convey meaning (see Bateman 2014; Kress & van Leeuwen 1996). Almost all e-book platforms allow the reader to interact with texts, for example by making notes which can be private or shared with other readers, to look up the definitions of words in the text and, often, to listen to the text being read aloud. There are a number of ‘learning to read’ apps that provide work-alone classroom e-learning for beginning readers. The app ‘Hooked on phonics’, for example, claims 5m users (2016). Multimodality presents many interesting design challenges but is beyond the scope of this chapter.

2 Considerations that affect designers’ decisions

Book and information designers are concerned with structuring a text so that its meaning is clear to readers. They use devices to help readers find their way around a text, such as headings, contents pages and indexes, and consider whether to organise the content as continuous text or, for example, as a list or a table. They think about where to position illustrations in relation to the text, as well as about the position of both illustrations and text within the format of a page or double-page spread. They choose typeface and type size for different elements of a text and use space to make the text easy to read. Design decisions about each of these are constrained by the technology that is used to produce and disseminate the text. Richard Southall (1984:83) used the term ‘graphic capability’ to refer to the potential of typesetting technologies to articulate document structure, describing it as constrained by ‘the number of characters, typefaces, and type sizes and the facilities for defining amounts of horizontal and vertical space, that the system offers.’

Constraints imposed by technology affect the design of devices used for e-reading. After Waller (2012) we use the term fixed layout when the positions of text and pictures on the substrate are fixed in relation to each other and to the boundaries of the substrate (as with PDFs, which may be scaled). A flowed layout is where the position of text and pictures may change according to the size and proportions of the substrate (e.g. on a Kindle) depending on the size of the device and its software capabilities as well as design parameters applied by

both designer and reader. For fixed page types designers have considerable control over the typographic variables, and print conventions remain relevant; for flowed page types there may be much less designer control, dependent upon the e-reading format. In flowed texts control may require considerable technical understanding to implement, together with significant resources for testing that the designed text auto-adapts successfully on a wide range of device formats and sizes.

In thinking about the reading needs of specific user groups as beginner readers, design decisions may be influenced by particular constraints. For example, in reading material for beginners, illustrations play a key role so designers are concerned to ensure that the text and related illustration(s), appear on the same page or double-page spread. This cannot be relied upon in e-books with flowed texts presented on a range of possible devices. Designers consider how the physical and material attributes of books may affect the child's reading experience. Some reading books, for example, are small enough to be easily manipulated by children's hands; 'big books' are designed to be read aloud, often with large groups of children.

In summary, the design of a specific book encompasses the visual experience of reading – navigation, page layout, illustration, typeface and typography as well as aspects of the physical experience: what it is made of, its size, texture, weight in relation to the reader and the circumstances of use. Design of a specific e-book can manage only the visual experience of reading, and then only within the constraints of the physical device. Other aspects of the reading experience are constrained by the design of the software (e.g. Kindle or iBooks), operating system (e.g. Android, Windows or Apple ios), and hardware (tablet, laptop, phone). Even e-books that display replicates of printed pages require different modes of interaction and engagement, for example, to navigate the text (Mangen 2016). The next section presents an overview of the multi-variate nature of typographic decision making followed by a more detailed account of typefaces, type size and the use of space, in relation to children's reading.

3 Typefaces, typography and the use of space

To describe the variables that affect text typography, Twyman (1982) introduced the terms 'intrinsic' and 'extrinsic'. Intrinsic features refer to properties of the characters themselves: typeface or style of letterform; character set (the characters that are available for use); variants of a typeface (italic, bold). Extrinsic features refer to what can be done to the characters by changing the space between or around particular characters, or their colours.

In print, intrinsic and extrinsic features of text affect whether or not text is comfortable and easy to read. In e-books, typographic choices extend to how links and interactive elements are signalled. Manipulating a single variable may lead to automatic changes in other variables. For example, if type size is increased, fewer words may appear on a line, possibly extending the content over more pages than in the original size; conversely, vertical line spacing may be reduced to accommodate the same content on a page, creating a denser appearing text; or, if line spacing adapts automatically to accommodate the increased size, content may be extended further over more pages. Changes in overall page format will be even more marked when examining factors such as the impact of illustration or other non-textual materials on pages. Although the impact of extending texts over multiple pages in ebooks for children has not been studied, there are indications from studies of adult readers using computers of a cognitive ‘cost’ of needing to make mouse clicks while reading prose (Wright, Lickorish & Milroy, 1994). This may be relevant to beginner readers having to read content across multiple pages, particularly those experiencing difficulties in reading.

The visual attributes of books for beginners stem from tacit knowledge based on typographic tradition, publishers’ expertise and teacher opinion (eg Raban 1984; Woods et al 2005). Typography in books for beginner readers has also attracted the attraction of psychologists interested in legibility research. For typographers, legibility research is a controversial field because the validity of some of the research is difficult to ascertain: test material is often not shown, and testing is undertaken in laboratory conditions rather than ‘real life’ settings (see Lund 1999; Bessemans 2012a; Beier & Dyson 2014). There is, however, increasing recognition that the gap between experimental results and design experience needs to be bridged (Dyson & Suen 2016), a notion eloquently expressed by Dillon (2004; 2016) in relation to designing usable electronic texts.

The integration of knowledge arising from research and from practice in defining the visual appearance of books for children’s reading has considerable historical precedent. Walker (2013) provides an historical overview of books for young readers in the UK for a hundred years from the end of the nineteenth century, drawing attention to the various factors that have influenced their design (teachers’ opinions; typesetting technology and available typefaces; economic constraints faced by publishers and views about legibility research and the effect of reading on a child’s eyesight). Her timeline of examples of books for children’s reading reveals a wide variety of approaches to their design, many of which would not accord with what we would think appropriate in the twenty-first century. In the 1920s, for example, it would have been conventional to set books for beginner readers in a large type size with justified lines (that is text aligned at both sides of the page), which meant that space between

words varied from line to line in order to make lines with slightly varying amounts of text fit (Figure 1). In this instance, justified setting was conventional in book production; using a large type size to protect children's eyesight was publishers' acknowledgement of recommendations in a report produced by the British Association for the Advancement of Science (1913).

Much of the early legibility research with relevance to children was undertaken in the context of 'school hygiene' and 'hygiene of reading', which aimed to ensure that the type that children read in their books did not harm their eyesight (see Huey 1908, Venezky 1984). This work led to recommendations for particular kinds of typeface, type size and spacing in books for beginner readers (eg Kerr 1904; Gunn 1906). Later legibility researchers, usually psychologists (including Cyril Burt, Miles Tinker and Bror Zachrisson), undertook work with young readers, testing different versions of a page of type (for example, showing variations in line spacing, line length and type size) and measuring speed of reading or comprehension. Watts & Nisbet (1974) provide a useful, concise review of this and other research relevant to typography in children's books, thereby drawing attention to the range of typographic variables that text designers have at their disposal when designing. Despite the volume of research there is still no consensus about the visual attributes of texts that are best for beginner readers, although most would agree that text should not be set in all capitals nor be justified. There remains debate as to whether serif or sanserif type is easier to read (Walker and Reynolds 2002/3), whether or not lines should be broken according to the sense of the text (Raban 1982), whether single-storey a's, g's and other infant character modifications should be used (Coghill 1980; Walker & Reynolds 2002/3), how much space should be used between lines and words (Haber & Haber 1981; Reynolds and Walker 2004; Reynolds et al 2006), and whether text for beginners should be set larger than that for more fluent readers (Hughes & Wilkins 2000; Wilkins et al 2009).

Typography on screen interested researchers with the growth of multimedia in classrooms and elsewhere in the 1980s and 1990s. Guidelines and primers introduced typography and page layout to new users of electronic publishing. For example, Rockley (1994) presented straightforward guidelines 'based on related research and practice', for the use of multimedia, and included 'novice' as one of her levels of user experience. Horton (1990) offered guidelines for the design of on-line documents, based on a literature review. Philips and DiGeorgio (1997) described and illustrated a number of alternative layout patterns for headings, text and illustrations. Walker & Reynolds (2000) summarised research relevant to screen design for children's reading, including navigation, typography and layout of text on a screen, and Dyson (2005a; 2005b) provided a more general review of research relevant to

reading on screen. Though much of this work relates to technologies no longer in use in classrooms, much of it affirms the guidelines presented in Table 1.

For children's reading there remains debate about which typefaces are most appropriate. Just as important, if not more so, is the relationship between size of type, space between the lines and letters, and the length of the line. These issues are discussed in the next section.

3.1 Typefaces

An issue that has interested both typographers and those engaged in legibility research is whether reading is better supported through distinctive word shapes (assuming word recognition is paramount), or easily distinguishable letter shapes (because readers build up words by recognising individual letters). Historically, a distinctive word shape has been promoted by designers as being key to reading, though with recognition that the features of individual letterforms (ie internal shapes, contrast between thick and thin strokes) also contribute to word recognition (see, for example, Spencer 1968). In the 1990s theories began to emerge suggesting that words may be recognised from a set of critical features, the majority of which were related to the distinctive features of individual letters and their position in a word (see Smith 1994: 119–131). Recent evidence has elucidated further the roles of letter by letter and whole word reading, and the aspects of letter design that contribute to their identification; this has been usefully summarised by Beier (2012: 22–30) with reference to related research. Pelli & Tillman (2007) examined the contribution of different processes underlying word reading and found that the three processes of letter by letter identification, whole word identification and use of context to predict words operate together in fluent readers, with letter by letter reading contributing more than the other two strategies. Other research suggests that word shape is not critical to word recognition (Larson 2004, Dyson 2013) and that words cannot be read if their individual letters are not individually identifiable (Pelli, Farell & Moore 2003). Letters are identified by detecting independent features (around 7 features per letter) (Pelli et al 2006). Fiset et al (2008) suggest that, in Latin script, the terminations (areas where strokes begin or end) carry the most significant cues to letter identification, with intersections, curves and direction of features also important. Cues to letter identification, of course, vary across scripts.

Type designers traditionally strive to create evenness and harmony in the appearance of the characters of a typeface. Improving legibility through modifying letters to increase their distinctiveness has been proposed (Fiset et al 2008) and explored (e.g. Kolars 1969; Beier &

Larson 2010). Studies aimed at less fluent readers focus on heterogeneity/irregularity among the characters as a means of improving reading. Wilkins et al (2007) introduced distortions to Times New Roman to create uneven strokes and distances between strokes. The reading rate of fluent adult readers was not affected, but children with literacy difficulties read the distorted words faster and with fewer errors. Wilkins has posited that this effect is due to disruption of the stripe patterns of lines of type on a page created by standard typefaces. Bessemans (2012) has found that a more irregular rhythm (and possibly form) facilitates reading of visually impaired children. Other studies suggest that consistency in letter appearance improves reading efficiency. Known as the font-regularity effect (Sanocki, 1987) or 'font tuning', the benefit of consistency is considered to be the result of the perceptual system developing a set of recognition parameters over time, which it can apply throughout a text (see Sanocki & Dyson 2012).

Clear distinction between letters is important for children's reading. A question often raised in relation to typefaces for children's reading is whether serif or sanserif typefaces are more appropriate (a serif type has small lines attached to the end of a stroke, a sanserif type does not). For example, many teachers favour the use of sanserif typefaces because they relate to letterforms that children are learning to write; but there has been no research that concludes that sanserif type is actually easier for children to read. Walker & Reynolds (2002/3) found that children read text set in serif (Century Schoolbook) and sanserif (Gill Sans) equally well. Bessemans (2012; 2016) found that the children (aged 5 to 10) made fewer mistakes when reading text set in a serified typeface (DTL Documenta) than when reading text set in Frutiger. Ripoll (2015) found that beginners could read cursive, serif and sanserif equally well (though they preferred the cursive one they were familiar with).

To further simulate handwritten forms, and at the request of teachers, many typefaces used in children's books are designed with alternative character shapes for some letters. typically those for a, g, l and t and capital I and figure 1 (Figure 2). Known as 'infant' or 'schoolbook' characters, they are similar in form to those that children learn to write. In some typefaces such practice means that there are similarities in letter shapes between; for example, in very round-looking typefaces with short ascending and descending strokes, lower-case o, a and g look very similar (Figure 3) and which can cause confusion at the word level. A study by Walker & Reynolds (2002/3) found no difference when children read text set with infant and with non-infant characters, although some noted that single-storey a and g were for writing, and double-storey ones for reading. Bessemans (2012; 2016) also found that children (aged 5 to 10) had no problems concerning the use of non-infant characters in type

Some typefaces have been designed especially for children's reading. In the 1980s, for example, Rosemary Sassoon produced Sassoon Primary. Designed in consultation with children, this typeface has characteristics of handwritten letterforms, notably a slight slant and 'exit strokes' to lead from one letter to the next (Sassoon 1993). Another approach has been to consider the characteristics that typefaces might have and whether these are likely to help with letter and word recognition, for example, long ascending and descending strokes. Fabula was designed as a screen font in the late 1990s to support bilingual story books for children. It aimed to make a distinction between characters that could be easily confused and to have a friendly and informal feel (see Figure 4). Twinkl, launched in 2016, shares many of Fabula's attributes, and is available in a series of weights (Figure 5).

3.2 Type size, vertical and horizontal space

In printed materials for adults it is generally accepted that, for type sizes for reading at normal distances, legibility is increased by adequate vertical separation of lines of type. In typographic terminology, this means the addition of two or three extra points of space. It is argued that the additional space makes it easier to follow each line, and facilitates an accurate, even sweep of the eyes from the beginning of each successive line (see Tinker 1968: 320). Generous space between lines may also help with word recognition, as there will be less visual interference or 'contour interaction' from lines above and below the line that is being read (Hughes & Wilkins 2002). The optimum amount of additional space depends on several factors, including the size of the type and whether it is sanserif or serif, and the length of the line. Precise metrics for spacing are therefore difficult to specify and are a further example of a decision designers make, based on experience. There has been very little experimental work on line spacing in books for children, and the results have generally been inconclusive (Tinker, 1968). Sassoon (1993) reported on a study with 8-13 year old children of different abilities who were shown examples of differently space text, and concluded that it is difficult to define a generally applicable practice as children at different levels of reading have different requirements and preference. This view was supported in qualitative studies undertaken by Reynolds & Walker (2006) who found that most of the children in their sample preferred a reasonably generous space between lines, with perceptions of a text that was very widely or very closely spaced, respectively, as 'did not look like a real book', or was 'too difficult'.

The optimum line length for reading printed texts, for adult readers, is between 50 and 70 characters, or 8-12 words (Spencer 1969; Hochuli 2008; Bringhurst 1992). Tinker (1968) conducted studies of line spacing with Grade 1 children (six- and seven-year olds). He

recommended that with 18- or 24-point type, lines should be relatively short, with 6 to 8 points of additional space. In practice though different 24-point typefaces have different appearing sizes (see, for example, Legge & Bigelow 2011); and the visual appearance is also affected by the space between the lines (see Figure 6). Taking a different perspective, Raban (1982) found that for beginning readers, breaking lines after ‘and’ and between phrases caused less disruption of reading than breaking according to line length. Following this phrase-based breaking practice resulted in lines of text of considerable variation in length, and a very ragged right-hand edge (see Figure 7).

Historically, horizontal space – between letters and words – has not been thought by legibility researchers to be as important as type size, line length and space between the lines (see Huey 1908; BAAS 1913). This may be due to the prevalence of justified setting, which effectively varies word spacing from line to line in order to maintain straight borders on both the left and right side of the page (Figure 8). Justified setting was used in reading books until around the mid-1940s, though in the 1920s some were set unjustified with even word spaces. Hartley (1987) concluded that unjustified text was more suitable for screen reading. In the latter part of the twentieth century it was fashionable in typography for adults for words to be very tightly spaced, a practice criticised by Yule (1988) and Sassoon (1993) with regard to children’s books. And following teachers’ opinions many educational publishers increased the space between words for beginners. Although in Raban’s (1984) study, teachers thought that spacing was less important than typeface or type size in choosing books for children, they thought that for beginner readers (5- and 6-year olds) word spacing was more important than line or letter spacing. In terms of whether more or less space between words helps beginner readers, Reynolds and Walker (2004) found that, with realistic reading materials discussed in a classroom setting, children were very tolerant in relation to variation in the use of horizontal space. As in Hughes & Wilkins’s (2002) study, they found that more or less horizontal space affected perceptions of ease of reading: that tight spacing looked ‘difficult’, or that wide spacing made type look ‘bigger and thinner’. The relation between word spacing and line spacing is also important. Typographers are concerned with ensuring that the space between the lines of type is greater than that between the words. If not, and especially if the text is justified so that the word spacing varies from line to line, distracting vertical ‘rivers of white’ may impede the reading process. This effect can often be seen in children’s reading books in the early part of the twentieth century.

4 Pictures and text

Book designers are concerned with the functional and positional relationship of text and image. There are a number of descriptive frameworks that define these, though most are more generally applicable than to children's reading (eg Williams 1993; Duschatel 1978; Emery 1993; Schriver 1997). Pictures also play a strong motivational role – if a book is visually attractive young readers are more likely to engage with it Levie & Lentz (1982).

Much of the early research that considers the relationship of text and pictures, including in reading primers, is summarised in Goldsmith (1984). Many studies, particularly those concerned with the acquisition of individual words, concluded that pictures were a distraction from word learning, though the validity of some of this work is questionable because the quality of the illustrations and test materials was poor and the results complicated or inconclusive. Kozma (1991) cited research by Winn (1989) which suggested that for knowledgeable readers, pictures should be placed early in the text if they are used at all, and that less knowledgeable readership would benefit from interspersed pictures, juxtaposed with the corresponding text. Horton (1990) concluded that related text and graphic should be placed next to each other and that this was more important than balancing text and pictures for aesthetic reasons. Goldsmith (1984), however, commented that if an illustration was positioned near the top of a page, readers are more likely to pay attention to the text that follows. She also commented on the converse – that a particularly attractive illustration placed at the bottom of a page may distract the reader from reading / being aware of the text above it (eg Peeck 1987; Filippatou & Pumfrey 1996). In practice there is considerable variation: Walker (2013) identified typical text/picture positional relationships evident in print reading books from the end of the nineteenth century until the beginning of the twenty-first.

What these analyses have in common is the recommendation that a picture should be in the same field of view as the text that relates to it. In e-reading, the ability of the designer to control the spatial relationship of picture to text may be limited. In fixed modes picture positions can be controlled precisely within a 'page' but in flowed modes much less so, and with more effort from the designer/developer. Custom applications offer the most control but in return for a large investment in design and development effort.

5 E-reading formats and the control offered to the designer

The design of pages for reading extends beyond the typography and use of illustrations discussed above. Designers must work within the constraints of the technology available to present text in a way that responds to the needs and expectations of readers, and to how and

where they read. The introduction of new technologies, from typewriters at the end of the nineteenth century, to desktop publishing in the 1980s influences how text is presented (Walker 2001). At each stage of technological transition there is a tendency for producers of text to replicate the conventions of the old technology that readers are familiar with, and then, as new technologies become familiar, for new conventions to become established. Design for reading, at least on paper is bound by conventions that affirm readers' expectations of visual presentation or graphic genres (Waller 1991; Kostelnick & Hassett 2003; Moys 2016). Conventions and reader expectations are not yet affirmed for e-reading, though research on the location of web objects (that is, any content contained in a web page) may provide useful pointers; see Bernard (2000, 2001); Shaikh & Lenz (2006); Roth et al (2010).

The visual experience that can be offered to beginning readers depends on:

- The physical size, colour gamut and pixel resolution of the hardware device on which the visual experience is rendered (see Sorkin 2016). These will affect the appearance of the text: for example, how crisp, black or grey letter images appear. There are (in 2016) a large number of variants in both the physical size and the pixel resolution of tablet devices used in classrooms, which makes it likely that different readers of the 'same' ebook will have different reading experiences.
- The format repertoire of the page description language, markup/browser combination or programming language used to render the reading experience to the display – that is, the graphic capabilities of the software. Software varies in its capability to draw shapes accurately, place items precisely on the display, select and render typefaces, place pictures etc. The combination of hardware device and software are the publishing 'platform'. There are many publishing platforms in the market and even the dominant one (Kindle) contains many significant variations caused by the different software versions and hardware platforms on which it is used.
- The locus of control over the graphic capabilities of the software; that is, *who* gets to choose how the software capabilities are rendered to the display surface for a particular device and *when* is that control exercised. For example, the reader of an e-book may be allowed to change the size of the type which they are reading to suit their preferences. The 'designer' may be able to specify a type size when formatting a particular e-book for publication. And the publishing platform may have limits on the range of sizes which can be selected for e-books published on

that platform, together with restrictions on how much the designer and the reader is able to change sizes within the system's limits.

All of the above vary in the e-reading experiences of beginner readers today. In an ideal world, teachers, publishers, designers, reading researchers and authors would select the publishing platform that best meets the child's needs and the nature of the e-reading material. In practice, factors such as market share of platforms, the need to use particular Digital Rights Management (DRM) systems to protect sales, compatibility with school-wide asset management systems, etc. are likely to be the main factors in choosing platforms. There are over 20 fairly widely-used technical standards that cover e-book formats, each supported by one or more e-book software applications. As technology develops, new standards are introduced and old ones sometimes superseded. A reasonably full listing of standards is available in Wikipedia at https://en.wikipedia.org/wiki/Comparison_of_e-book_formats. These standards vary widely but fall into main categories plus a few 'exceptions'. The next two short sections summarise the technical constraints imposed by flowed and fixed page layouts.

5.1 Markup-based e-books: flowed page layout

Most e-reading file standards are based on 'semantic markup' of the text and pictures in a book. The markup is then combined with 'stylesheets' to control how those elements appear on the e-reader screen (see Goldfarb & Rubinsky, 1990, for the principles of separating the semantics and appearance of documents). This is essentially the same process that is used to create web pages, and many e-reading file standards are closely based on the HTML (Hypertext Markup Language) and CSS (Cascading Style Sheets) standards. None, however, are entirely compatible with HTML/CSS (HTML contains text and codes which identify whether each part of that text is a paragraph, a heading, a hyperlink, etc. CSS is a 'style sheet' which says how a paragraph etc. should be displayed: its colour, typeface size, line spacing etc.). Moreover, most incorporate optional or required use of proprietary digital rights management software, to prevent unauthorised copying of the e-book. This adds some complexity to the design process.

On the web, pages are viewed in internet browser software such as Internet Explorer, Chrome or Firefox. A given set of HTML and CSS files will display near-identically on any web browser, and open standards for HTML/CSS specify what that appearance should be. E-reader software products such as Kindle or iBook can be seen as 'browsers' for one or more e-reading file formats. They often require, or focus on, proprietary markup and style formats,

so there is no real equivalent of the consistency in appearance across web browsers. Where E-readers do support ‘open’ standards such as EPUB2 or EPUB3, they tend to do so in idiosyncratic and partial ways (IDPF 2010).

All e-book software can accept and display ‘flowed’ books provided in ‘EPUB’ markup defined by the International Publishing Forum (<http://idpf.org>). Designers influence the look and behaviour of an EPUB e-book mainly by creating CSS stylesheets for it. The resulting EPUB file is submitted to an e-book publishing service, such as Kindle, Apple i-book or Android Play, and is in turn made available to users of appropriate devices and services. This process creates different user experiences on different devices and services even if the same original code is submitted. For example, on a Kindle, the designer’s style instructions for space between the lines may be overridden by Kindle’s defaults (or by the user’s stored preferences). This limits the control the designer has over the user/reader experience. Current developments in e-reader standards and devices e.g. EPUB 3 are tending to increase the control over the reading experience available to designers (<http://epubtest/testsuite/epub3/>).

5.2 Pictures of pages: fixed page-layout

Most e-reading platforms support one or more fixed layout file format, most commonly PDF, or a format based on PDF. Most integrated texts – books with large numbers of illustrations and close relations between text and image – are carefully-designed for print and published electronically as ‘pictures of pages’. The key advantage of fixed layouts is that designers have complete control over how the page is arranged. PDFs may be appropriate in situations where the physical size, resolution and operating system of users’ devices is controlled and consistent; this may be true within a particular institution or school system. However, fixed layouts have disadvantages for a number of reasons including:

- accessibility features such as read-aloud may be unavailable
- by default fixed-layout formats ‘scale’ to the size of the device they are displayed on. Type and pictures are likely to be displayed at a different (normally smaller) size than they were designed for. The user can normally enlarge by zooming into a part of the page, sacrificing a complete view of the page as it was designed.

The impact of these features on usability will depend on the particular e-book or series of e-books (for example, a publisher’s integrated reading scheme) and would need specific usability testing. There are therefore no generally-applicable research results to provide guidance.

6 Finding out what works with beginner and emerging readers

The impact of technology on the visual attributes and materiality of e-reading, and the resulting variations that occur emphasise the importance of eliciting feedback from users as part of the design process. Involving children in this is regarded as good practice in HCI (eg Druin 2002; Bruckman et al 2012; Nielsen 2010). Druin, for example, identifies the roles that children have assumed: from ‘users’ to ‘testers’, ‘informants’ and, latterly, ‘design partners’, summarising the historical context of each approach, the methods used, the impact on the technologies concerned, and the challenges and strengths of working with children in each case. Information designers also take seriously the need to involve the readers and users of their work in its development and typically elicit feedback through:

- observation and feedback sessions to discover how children use and report using reading materials, with a view to understanding what works well within a particular learning setting (see eg, in relation to classroom use of CD-ROMS, Walker, Reynolds & Edwards 1999)
- exploration of whether there are specific aspects of the design of e-books that affect an individual child’s reading
- user testing to find out whether materials under development are easy for children to read and use; in this case, aspects of the design that appear to cause difficulties can be revised and the materials re-tested in an iterative process
- preference judgements, which may produce generalizable findings, to discover whether different devices and/or layout strategies have different levels of appeal to children; children may make their choice of books according to different design criteria from those of teachers, parents, or other adults.
- investigative examination, to produce generalizable findings, of whether there are aspects of the design of materials that affect the reading performance of children at different stages of reading development; such investigation may focus on specific reading tasks, such as letter, grapheme or word recognition, sustained reading or searching for information within a page or a document.

These approaches vary both in their intentions – from diagnostic testing to investigative research and in the level of formality of the investigation; see Dyson (2016) for a characterisation of different types of testing according to purpose. Depending on the goal of testing e-books or other digital reading materials, study tasks may range from group discussions to individual testing of reading performance. Studies of performance may yield information about the process of reading (for example, by tracking eye movements and the characteristics of reading errors or pages accessed) or its outcomes (the time taken to read,

comprehension, successful retrieval of information); see Dillon, 2004, for further discussion of the process–outcome distinction.

As we have seen, the design of texts of any kind involves the manipulation of multiple variables, from typeface choice, size, line length, vertical spacing of lines, through the number of lines on a page, the differentiation of different types of text (for example, headings and paragraphs). A process of decision-making is needed in order to decide which variables are most important to control and which allow to vary in order to examine the specific issue of interest. Options for controlling typographic variables may be limited in published e-books but it is still important to be aware of them and their potential effects on readers' responses. Involving a designer with experience in text design may help steer decisions about which variables to hold and which to co-vary with the manipulated variable. Options for controlling these variables may be limited in published e-books but it is still important to be aware of them and their potential effects on readers' responses.

7 Concluding remarks

As this chapter has discussed, there is limited research on the impact of visual design of digital reading materials on children's ability to carry out reading tasks. Although much research from printed materials is likely to be transferable to on-screen materials there are still unknown factors. How far, example, does the relative brightness of digital displays affects children's reading? How does the physical form of e-readers and tablets and the different cues to position within a text they provide affect children's reading eg motivation, information access, ease of reading, and satisfaction. Lack of research into these issues contrasts to research which has focused on the multi-modal and interactive potential of e-books; for example, de Jong & Bus (2003), Kurcicova, Littleton & Cremin (2015). Similarly, although reading research indicates the importance of *choice* of materials (see, for example, reviews by Gambrell 2011, and Wigfield & Guthrie 2000) there is limited research on the how the design of reading materials might influence choice. As discussed above, children's perceptions of books are likely to influence their willingness to start or persist in reading them (see Walker 2005). Many contemporary children's books reveal considerable typographic variety including words in all-capitals that 'shout'; words and phrases in bold to emphasise something important; different typefaces mixed in the same word; and straight and curved lines within a single page. Some children are motivated by such variety and it is likely that they may be motivated by the options that some digital devices offer for manipulating the text: if a word or concept is not understood they can look it up; when text is not big enough they can increase the size and so on.

In this chapter we have drawn attention to evidence from research and practice that provides some general indication of the treatment of the features that are likely to help beginner and emerging readers (see Table 1). Awareness of these will assist in discussions between educationists and designers, and may inform design decisions relevant to fixed modes of e-readers.

In the absence of evidence on which to base clear recommendations for e-reading, we recommend that obtaining feedback from children and teachers (through surveys, performance and preference testing) is essential for successful reading. This way of working also has historical precedent in information design in non-educational contexts (see examples in Black et al, 2016) and demonstrates further value in working with insights obtained through evaluating documents with intended users, and within particular contexts of use.

Looking ahead, design for e-reading requires collaboration between, and involvement with children, teachers, and technicians. Information designers welcome this way of working, and also understand the relationship between language and its visual presentation, whether through type or images. In the words of Andrew Dillon (2016: 298):

Much as doctors use test findings and medical science in a skilled reading of contexts and patients to reach a diagnosis, a skilled designer needs multiple forms of knowledge to make the right choices. The science does matter, the principles of good design will always apply, but creating useful, usable, and attractive information tools requires a representation of human actions in context to enable appropriate design constraints to be envisaged. Such representations are worthy of our serious attention now.

Table 1 A summary of issues, and treatment of typographic features that are likely to benefit children's reading

Issues that designers consider when making books for beginner and emerging readers	Treatment of typographic feature
Treatment of line-endings	Unjustified/ranged left so that the space between words is

	<p>even (Hartley & Burnhill 1971; Hartley 1987)</p> <p>Break lines according to sense and to anticipate words on a following line. (Raban 1982)</p>
Spaces between words and lines	A little wider than for adult reading (Reynolds & Walker 2004; Hughes & Wilkins 2002a)
Space between the lines and length of lines	<p>The appearing space between the lines should be greater than that between the words so that lines of type are clear.</p> <p>Longer lines require more space between them than shorter ones.</p> <p>(Reynolds, Walker & Duncan 2006; Sassoon 1993; Hughes & Wilkins 2000; Phillips & di Georgio 1997)</p>
Treatment of paragraph beginnings	<p>Research with children using printed materials suggests that either a line space with no indent, or an indent with no line space are likely to be equally suitable. A new line with no additional space is likely to be less helpful.</p> <p>(Hartley, Burnhill & Davis 1978)</p>
Typeface or font	<p>Both serif and sanserif typefaces are suitable for beginner and emerging readers. (Walker & Reynolds 2002/3; Bessemans 2012; Rippol 2015)</p> <p>There should be clear differentiation between the character shapes of letters that might be confused, eg o and a; h and n. Discriminability can be helped through, for example, using a non-infant d and g; using a font with long ascending (for example for 'h's and 'k's) and descending strokes (for example, for 'y's and 'g's). (Walker 2005)</p>
Type size	<p>Generally, type should be set larger than for adult readers. However, the space between the lines and the length of the line contribute to the perceived appearing size of the type.</p> <p>(Woods et al 2005; Walker 2005; Rippol 2015)</p>

Pictures and text	Related text and pictures should be adjacent, (rather than positioned for aesthetic reasons).
Headings	<p>A heading should relate to the text that follows it. There should be more space above than below to help readers with this.</p> <p>Designers use headings and sub-headings to clearly articulate a visible hierarchy using, for example, size, boldness and indentation</p> <p>(see, for example, Hartley & Trueman 1985)</p>

8 References

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SIX WEE CRABS.

1. Mama Crab saw Jim and Joe put the six crabs in the net. She was so sad, but she said, "I will get my crabs if I can." She hid in a pool.

2. Jim and Joe saw the pool. "Let us go in the pool," said Joe; "I am so hot. It will be cool in the pool." So into the pool he ran; Jim ran in, too.

3. "Ha! Ha!" said Mama Crab. "I will get you. I will get you." She ran to Joe and bit his big toe.

Figure 1

A page from 'Ring-o-roses series', *Six wee crabs*, London: Cassell & Co, c. 1929.

24-point type is set with no additional line feed; this and that the text is set justified (that is, with a straight right-hand edge) means that the word spacing varies from line to line. This arrangement is unlikely to benefit children's reading.



Figure 2

'Infant', 'schoolbook', 'single storey' are all terms used to describe alternative forms of some letterforms that are thought to be helpful for beginner readers. Sometimes letters are redrawn to look like handwritten forms; sometimes they are drawn to be clearly distinguished from similar-looking letters. The most widely-used infant characters are 'a' and 'g', and letters that might be confused such as capital I, lower-case 'el' and figure one.



Figure 3

In some typefaces, such as Avant Garde Gothic, shown here, there is very little differentiation between the letter shapes, and this is likely to confuse beginner readers.

Shep was the sheepdog, but he
did not like sheep. He said they
were silly and boring.



Figure 4

The typeface Fabula was designed to have generous ascenders and descenders, differentiation between a and o, and rounded stroke ends to give a friendly and informal feel. There is a clear distinction between characters that might be confused.

Shep was the sheepdog.

Shep was the sheepdog

Shep was the sheepdog

Shep was the sheepdog

Shep was the sheepdog

Figure 5

The typeface Twinkl shares many of the characteristics of Fabula.

It is available in a range of weights.

[thanks to Twinkl educational publishers and to Type Together]

Figure 6

Examples of 24-point type set according to the parameters set out by Tinker (1968), for 6-7 year old children. It shows that different typefaces have different appearing sizes. The typefaces shown are Century Schoolbook, Twinkl, Gill Sans and Garamond.

But Shep was a good dog. So every day
he sat with his nose on his paws and
counted sheep. Then one day he fell
asleep.

But Shep was a good dog. So every day
he sat with his nose on his paws and
counted sheep. Then one day he fell
asleep.

But Shep was a good dog. So every day he
sat with his nose on his paws and counted
sheep. Then one day he fell asleep.

But Shep was a good dog. So every day he sat
with his nose on his paws and counted sheep.
Then one day he fell asleep.

But Shep was a good dog.
So every day he sat with his
nose on his paws and
counted sheep.

Figure 8

Breaking lines according to sense, or to anticipate the word on the following line may help beginners keep track of the sense of the narrative.

Figure 9

Examples of space between words and line endings

But Shep was a good dog. So every day
he sat with his nose on his very big paws
and counted sheep.

Unjustified setting – where the space between words is equal – is recommended for beginner and emerging readers, and words should not be hyphenated

But Shep was a good dog. So every day
he sat with his nose on his very big paws and
counted sheep.

Justified setting results in a straight right-hand edge and the space between the words varies from line to line.